



This document was prepared by collaborators from

Lund University, Sweden

University of California- Los Angeles, United States

University of Virginia, United States

National Aeronautics and Space Administration, United States

# README Document for the High Resolution Altitude Corrected – Tropical Rainfall Measurement Mission TRMM/TMPA and Other Sources Monthly Rainfall Product 3B43 for the Conterminous United States

Last Revised August 27, 2019

Prepared by:

*Jessica Fayne*  
University of California, Los Angeles (USA)

*Hossein Hashemi*  
University of Lund (Sweden)

*Venkataraman Lakshmi*  
University of Virginia (USA)

*George Huffman*  
NASA Goddard Space Flight Center (USA)

*08/27/2019*  
Date

Reviewed by:

*Reviewer Name*  
Reviewer Name

*Date*  
Date

## Revision History

Revision Date	Changes	Author
August 27, 2019	This document was first created.	Jessica Fayne et al.
September 4, 2019	Identified netCDF-4 as sole dataset format	David Silberstein

## Table of Contents

Introduction	5
Dataset Description	5
Algorithm Background	6
Data Disclaimer	7
Data Organization	7
Data Contents	7
Options for Reading the Data	8
Acknowledgements	8

## Introduction

This document provides basic information for using the High Resolution Altitude Corrected – Tropical Rainfall Measurement Mission TRMM/TMPA and Other Sources Monthly Rainfall Product 3B43 Product for the Conterminous United States, (HRAC\_Precip).

HRAC\_Precip is a product used for studying monthly precipitation in high altitude regions of the western United States. This product is a modification of the previously published TRMM/TMPA 3B43 product. The Tropical Rainfall Measurement Mission (TRMM) satellite was launched in the fall of 1997 and decommissioned in 2015. Thusly, the HRAC\_Precip dataset follows the lifespan of TRMM, with monthly data from 1998 to the end of 2014.

## Dataset Description

The dataset is a modification of a previously published dataset, TRMM/TMPA 3B43. The following table highlights the spatial resolution difference between the two datasets.

Users are advised to read the ‘README Document for the Tropical Rainfall Measurement Mission (TRMM) Version 7’ for more details on how the original TRMM/TMPA 3B43 product was produced.

	Product ID	Product Name	Temporal Resolution	Horizontal Resolution (x and y)
Gridded	3B43	TRMM/TMPA and Other Sources Monthly Rainfall Product	Monthly	0.25°
	HRAC_Precip	High Resolution Altitude Corrected 3B43	Monthly	0.01°

## Algorithm Background

This section describes how the HRAC\_Precip dataset was created, and is a summary of the peer reviewed data descriptor (*in progress*).

### *Elevation-Based Linear Correction Model*

We produced high-resolution altitude corrected monthly satellite data, based on a correction model proposed by Hashemi et al. (2017). The correction model reduces the mean absolute error of the satellite bias at the elevations above 1,500 meters by 5% across all seasons. Because biases are negligible below the 1,500 m elevation and lower elevations are not susceptible to orographic lifting and therefore underestimation by the microwave sensor, the correction is only applied to elevations above 1,500 meters. Thus, the primary assumption of the model is that the bias has a strong dependence on elevation and topography. The correction model is a linear function and assumes the dependence of relative bias in the satellite data, at the pixel level, on elevations above 1,500 m.

Calibration of the model and coefficient estimation are carried out at the pixel level using the Monte Carlo Cross Validation technique for each month. Computed coefficients are then validated against the topographically corrected Parameter-elevation Regressions on Independent Slopes Model (PRISM: Daly 1994 and 2008), ensuring that the corrected data rightfully incorporates topographically dependent corrections inherent in PRISM, such as wind direction, aspect, topographic position, and others.

### *Interpolation/resampling and spatial resolution*

To produce the High Resolution Altitude-Corrected (HRAC)\_Precip, an elevation dataset and satellite data matching the spatial resolution of the elevation is required. The original TMPA 3B43 product was resampled into the GTOPO30 DEM grid size (~1 km or 0.01°). This was done using nearest neighbor resampling to preserve all of the original values from 3B43. Each 0.25° pixel was subdivided into approximately 900 smaller (30 arc-second) pixels, each containing the original 0.25°-pixel value, representing the original spatial average for the region. This provides a precipitation dataset on the DEM spatial grid.

The correction model was applied to satellite data that was resampled to 0.01 degree resolution at the pixel level for each month corresponding to the appropriate monthly coefficients. Using the linear correction formula, the resampled satellite data, and a 0.01 degree high resolution elevation model together produce unique precipitation values for each month across the high altitude terrain.

## Data Disclaimer

The HRAC\_Precip products currently only cover the conterminous United States. Due to the processing methodology, values that appear anomalous or spurious in the original TMPA 3B43 product are amplified in the HRAC\_Precip product. For clarification, users may wish to view the products side-by-side in their region of interest to determine if the lower resolution product is more appropriate for their study.

Data products are released to the public as-is.

## Data Organization

The HRAC\_Precip dataset is stored in monthly files as NetCDF-4 (.NC) files.

File names have the following attributes:

- <product\_name> The name is always the abbreviation for the High Resolution Altitude Corrected Tropical Rainfall Measurement Mission TRMM/TMPA and Other Sources Monthly Rainfall Product 3B43 for the Conterminous United States, as <HRAC\_Precip>.
- <product\_version> As this is the first public release of the product, the product is version 1.
- <date> The date is always in a format with a four digit year, followed by a two digit month, and ending with a two digit day (always 01). For example August 01, 2019 would be 20190801.
- All products are produced as mm/hr/month, that is the average amount of precipitation in mm per hour across the entire month as <mmhr\_month>

## Data Contents

Resolution:

The altitude-driven orographic correction involves rescaling that changes the original resolution from 0.25° to 0.01°. All data are available at monthly temporal resolution, as the modified version is meant to augment studies that might have used the original 0.25° data over the conterminous United States.

## Options for Reading the Data

The data are available in NetCDF format to be read in a variety of different programming languages and software packages. NetCDF data can be drag/dropped into many geographic information systems software such as QGIS, ArcMap (ESRI Suite), WhiteBox GAT, and others. The NetCDF data can also be viewed using the NASA GISS Panoply software tool and HDFView.

Both formats can be read in programming languages such as Python, R Statistical Programming, Matlab, IDL, and C/C++. For more details on reading NetCDF files, please refer to the HDF-EOS Tools and Information Center (<http://hdfEOS.org/software/library.php>) and Data Services and Tools for Geoscience (<https://www.unidata.ucar.edu/software/netcdf/>).

## Data Citations and Acknowledgments

Hashemi, H., Nordin, M., Lakshmi, V., Huffman, G. J. & Knight, R. Bias Correction of Long-Term Satellite Monthly Precipitation Product (TRMM 3B43) over the Conterminous United States. *Journal of Hydrometeorology* **18**, 2491-2509 (2017).

Hashemi, H., Fayne, J., Lakshmi, V., Huffman, G. J. Very high resolution altitude-corrected, TMPA-based monthly satellite precipitation product over the CONUS. *Scientific Data (In Review)*.

Huffman, G. J., Adler, R. F., Bolvin, D. T. & Nelkin, E. J. The TRMM multi-satellite precipitation analysis (TMPA) in *Satellite rainfall applications for surface hydrology* 3-22 (Springer, 2010).

Huffman, G. J. *et al.* The TRMM multisatellite precipitation analysis (TMPA): Quasi-global, multiyear, combined-sensor precipitation estimates at fine scales. *Journal of Hydrometeorology* **8**, 38-55 (2007).

Simpson J., Adler, R.F., and North, G.R., 1988: A proposed tropical rainfall measuring mission (TRMM) satellite. *Bull. Amer. Meteor. Soc.*, 69, 278–295.

If you use these data in publications, please acknowledge the HRAC\_Precip, TMPA-3B43 Tropical Rainfall Measuring Mission (TRMM) as well as the Goddard Earth Sciences Data and Information Services Center (GES DISC) for the dissemination of the data.

GES DISC would appreciate receiving an electronic copy of your publication, which can be sent via email to [gsfc-dl-help-disc@mail.nasa.gov](mailto:gsfc-dl-help-disc@mail.nasa.gov).

Inquiries regarding the data product can be directed to Jessica V. Fayne at [jfayne@g.ucla.edu](mailto:jfayne@g.ucla.edu).